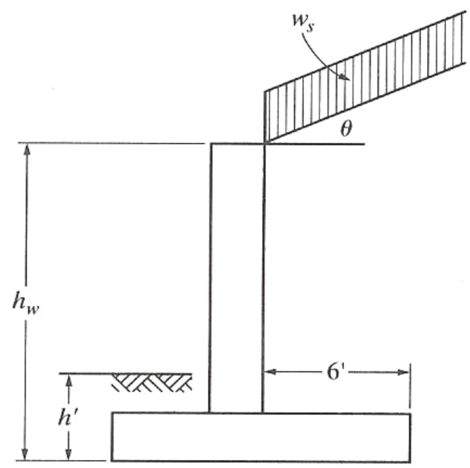
Solution to Homework Set #9

ENCE 454 – Design of Concrete Structures – SPRING 2004

Assigned Th, 4/29 Due Th, 5/6

Problem 1:

Compute the active earth pressure horizontal forces on the wall shown for the following conditions. Use w_e = 100 lb/ft^3.



Case	ϕ	θ	w_s (psf)	h_w (ft)
(a)	30	0	200	20
(b)	33	20	0	25

***** SOLUTION *****

CASE (a):

$$K_a = \frac{1-\sin 30}{1+\sin 30} = 0.333, \qquad h_{su} = \frac{200}{100} = 2 \text{ ft}$$

$$H_a = \frac{1}{2}K_a w_e h_w^2 = \frac{1}{2}(0.333)(0.100)(20)^2 = 6.67 \text{ kips/FT of wall}$$

$$H_{su} = K_a w_e h_{su} h_w = (0.333)(0.100)(2)(20) = 1.33 \text{ kips/ft of wall}$$

Therefore,

The total horizontal force = $H_a + H_{su}$ = 6.67 + 1.33 = **8.0 kips/ft of wall**

CASE (b):

$$K_a = \cos\theta\left(\frac{\cos\theta - \sqrt{\cos^2\theta - \cos^2\phi}}{\cos\theta + \sqrt{\cos^2\theta - \cos^2\phi}}\right) = \cos 20\left(\frac{\cos 20 - \sqrt{\cos^2 20 - \cos^2 33}}{\cos 20 + \sqrt{\cos^2 20 - \cos^2 33}}\right)$$

$$= 0.36$$

$$h_b = h_w + 6\tan\theta$$
$$= 25 + 6\tan 20 = 27.18 \text{ ft}$$

$$H_H = H_s \cos\theta$$
$$= \left(\frac{1}{2}K_a w_e h_b^2\right)\cos 20 = \frac{1}{2}(0.36)(0.100)(27.18)^2\cos 20 = 12.5 \text{ kips/ft of wall}$$

Therefore,

The total horizontal force = $H_a + H_{su}$ = 12.5 + 0.0 = **12.5 kips/ft of wall**

Problem 2:
Find the passive earth pressure force in front of the wall for Problem 1(a) if h' = 4 ft.

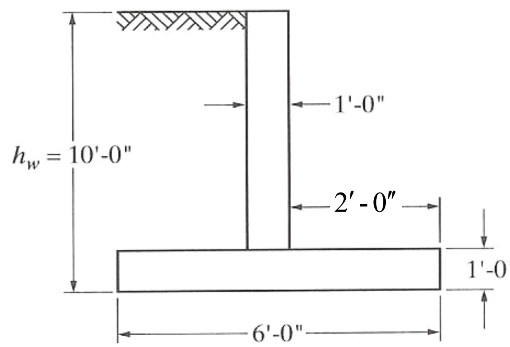
<u>***** SOLUTION *****</u>

$$K_p \frac{1+\sin\phi}{1-\sin\phi} = \frac{1+\sin 30}{1-\sin 30} = 3.0$$

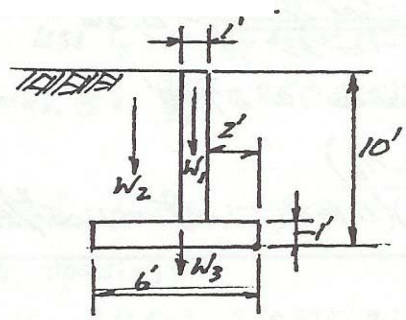
Therefore,

$$H_p = \frac{1}{2}K_p w_e (h')^2 = \frac{1}{2}(3.0)(0.100)(4)^2 = \boxed{2.4 \text{ kips/ft of wall}}$$

Problem 3:
For the wall shown in the figure, determine the factors of safety against overturning and sliding and determine the soil pressures under the footing. Use K_a = 0.3 and w_e = 100 lb/ft^3. The coefficient of friction f = 0.50.



<u>***** SOLUTION *****</u>



STABILIZING MOMENT (ΣM_{TOE})

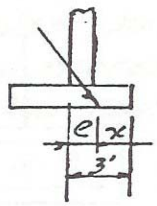
FORCE	MAGNITUDE (KIPS)	LEVER ARM (FT.)	MOMENT (FT-KIPS)
W_1	(1)(9)(0.150)=1.35	2.5	3.38
W_2	(3)(9)(0.100)=2.70	4.5	12.15
W_3	(1)(6)(0.150) 0.9	3.0	2.70
	$\Sigma W = 4.95^k$		$\Sigma M = 18.23^{1k}$

HORIZ. FORCE & OVERTURNING MOMENT SAME AS PROB 8-3

$$F.S.\ OVERTURNING = \frac{18.23}{5.0} = 3.65$$

$$F.S.\ SLIDING = \frac{0.5(4.95)}{1.50} = 1.65$$

SOIL PRESSURES & LOCATION OF RESULTANT FORCE:



$$x = \frac{18.23 - 5.0}{4.95} = 2.67'$$

$$e = \frac{6.0}{2} - 2.67 = 0.33' < \frac{6.0}{6} = 1.0 \quad \text{(OK)}$$

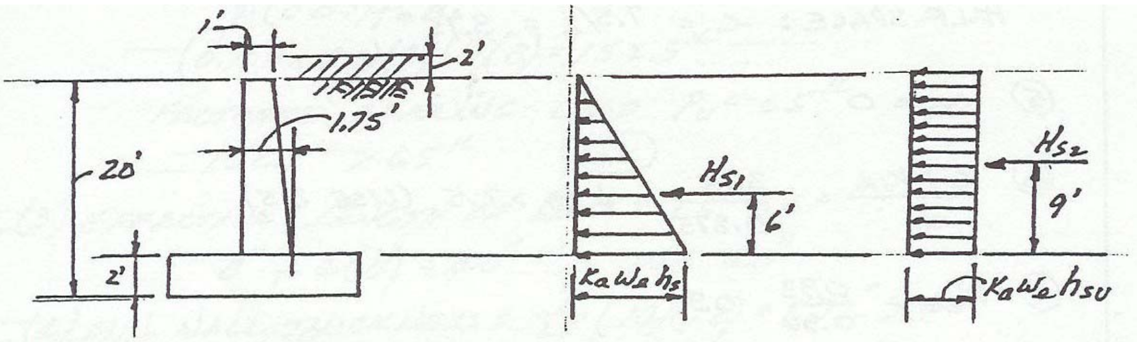
$$p_{max/min} = \frac{\Sigma W}{L}\left(1 \pm \frac{6e}{L}\right) = \frac{4.95}{6}\left(1 \pm \frac{6(0.33)}{6}\right)$$

$$p_{max} = 1.10\ ^{k}/_{FT^2}, \quad p_{min} = 0.55\ ^{k}/_{FT^2}$$

Problem 4:

In Problem 1(a), assume a footing depth of 2 ft. Design the stem steel for M_u at the top of the footing. **Do not** check for anchorage into the footing. Disregard other stem steel details. Use f_c' = 4000 psi and f_y = 60,000 psi. Use thickness at top of stem = 12 in. and thickness at bottom of stem = 1 ft-9 in.

***** SOLUTION *****



HORIZ. LOADS AT TOP OF FOOTING:

$$H_{S1} = \frac{1}{2} K_a w_e h_s^2 = \frac{1}{2}(0.333)(0.100)(18)^2 = 5.40\ ^{k}/_{FT}$$

$$H_{S2} = K_a w_e h_{su} h_s = (0.333)(0.100)(2)(18) = 1.20\ ^{k}/_{FT}$$

DESIGN MOMENT M_u & SHEAR V_c

$$M_u = 1.6\left[(5.40)(6) + 1.20(9)\right] = 69.12 \text{ ft-kip}$$

$$V_u = 1.6\,(5.40 + 1.20) = 10.22 \text{ kips}$$

EFFECTIVE DEPTH: (Assuming 2" cover & #8 BARS)

$$d = 21 - 2 - 0.5 = 18.5 \text{ in}$$

CHECK SHEAR:

$$\phi V_n = \phi V_c = \phi(2)\sqrt{f_c'}\, b\, d = 0.85(2)\sqrt{4000}\,(12)(18.5)$$

$$\therefore \phi V_n = 23.9 \text{ kips}$$

Since $V_u < \phi V_n$, thickness (OK)

TENSILE REINFORCEMENT:

$$\text{Req'd } R = \frac{M_u}{\phi b d^2} = \frac{69.12\,(12)}{0.9\,(12)\,(18.5)^2} = 0.2244 \text{ ksi}$$

$$= 224.340 \text{ psi}$$

From Table A-6 (Handout)

$\rho = 0.0039$ $(R = 225.95 \text{ psi})$

$\therefore$ Req'd $A_s = 0.0039(12)(18.5) = 0.87 \text{ in}^2/\text{ft}$

$A_{s,min} = 0.0033(12)(18.5) = 0.73 \text{ in}^2/\text{ft} < 0.87 \text{ in}^2/\text{ft}$ (OK)

Therefore,

Use #6 @ 6" ($A_s = 0.88 \text{ in}^2/\text{ft}$)